LONG-TERM RESPONSE OF COMPETING VEGETATION TO MECHANICAL SITE PREPARATION IN PINE PLANTATIONS[1]

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Abstract.-- Surveys of plant crown cover on permanently-marked transects and measurements of foliage biomass from separate destructively-harvested biomass plots on two watersheds subjected to quite different regeneration regimes showed quite different post harvest succession through 7 years. Planted slash pine (Pinus elliottii) grew faster on the area which had less competition because of more intensive site preparation. *Ecological and economic costs of the gain in pine fiber are* described. 3

INTRODUCTION

Mechanical site preparation prior to planting has en an accepted practice for southern pine management r over 20 years. Improved seedling survival and creased growth have been demonstrated for both lob- lly pine (Pinus taeda L.) and slash pine (Pinus el- ottii Engelm.) over a range of sites, from the edmont to the wet savannas of the coast. Site *eparation is almost universal in the pine flatwoods* ere the low relief, sandy soils, and large block nerships combine to make these sites favorable to chanized operations.

The objectives of mechanical site preparation on e sandy flatwoods soils are:(1) improvement of micro- te conditions (light, moisture, soil physical operties, and nutrient availability); (2) reduction competition from other vegetation, and; (3) duction of logging slash and residual vegetation to cilitate planting (Crutchfield and Martin 1982).

Early growth of southern pines can be increased rkedly by reduction of woody competition (Cain and Mann 1980, Pienaar and others 1983). Control of competing herbaceous vegetation in young stands of southern pines can also result in growth responses. This has been shown for loblolly pine (Bacon and Zedaker 1985, Cain and Mann 1980, Knowe and others 1985, Nelson and others 1981, Smith and Schmidtling 1970, Tiarks and Haywood 1986) and slash pine (Baker 1973). Long-term reduction in competing vegetation may be more important than widely realized. For both slash pine (Haines 1981) and loblolly pine (Langdon and Trousdell 1974) there is an inverse relationship between the amount of hardwood competition and pine growth. Data summarized by Glover and Dickens (1985) showed that this relationship holds throughout the rotation. Thus, as noted by Burkhart and Sprinz (1984), once hardwood competition becomes established it often remains a constant proportion of the stand growing stock over the rotation, diminishing pine yields. Conversely, the more site preparation reduces hardwoods the less there will be in the plantation and the higher the expected pine yields.

This paper addresses the efficacy of two different site preparation regimes in flatwoods with respect to reduction of competing vegetation and growth of planted slash pine. In particular, the initial reduction in competing vegetation and its regrowth is documented, *along with tree growth, over a period of 7 years* following regeneration.

MATERIALS AND METHODS

Study Site

The study site is two of three contiguous experimental watersheds *in Bradford County, FL-- part of a* large (>20 thousand ha) tract of open pineland (68%) and interspersed wooded swamps typical of Coastal Plain flatwoods. The tract had been frequently burned and heavily grazed prior to being acquired in 1938 by Container Corporation of America which instituted fire and cattle exclusion policies and seed tree forest management. Recently maturing pine stands on the tract have been converted to plantations.

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[3] Container Corporation of America provided nds and fire protection, and imposed the prescribed eatments. Dr. Louis F. Conde, deceased, inspired and ided this study from inception through 1984.

On the 67-ha watershed 1 (WS 1), pinelands comprised 49% of the watershed while a shallow, mixed pine and hardwood swamp occupied an interior 51% of the site. On the 49-ha watershed 2 (WS 2), pinelands comprised 74% of the area while several scattered, smaller swamps occupied the remaining 26%. Swindel and others (1982) described soils, typography, climate, and hydrology, and displayed an aerial photograph of these watersheds.

Treatments

Pinelands of WS 1 were clearcut harvested and site prepared by methods deemed to minimize destruction of residual understory, and soil and litter displacement, while permitting machine planting. In November and December 1978, all merchantable (> 10 cm DBH) pine trees were felled, delimbed, sectioned, and stacked by hand for transport from the woods by a small (56 kw) rubber-tired tractor with hydraulic grapple and wood rack. Logging debris and residual vegetation were chopped with a roller drum chopper (Fisher 1981) in April and again in August 1979. Planting beds were formed in September and October by a single pass of a bedding plow (Fisher 1981) and machine planted in November 1979 with a nominal 1,850 1-0 slash pine seedlings per ha. For convenience, we refer to this treatment as minimum site preparation, or minimum treatment.

Pinelands of WS 2 were harvested and site prepared by combining all those methods common in the ecosystem deemed to maximize destruction of residual understory and soil and litter displacement. In November and December 1978, all merchantable (> 13 cm DBH) pine were sheared at the stump with a feller-buncher (Conway 1976) and dragged, crowns intact by large (97 kw) skidders (Conway 1976) to central loading areas where tree length boles were removed to a rail siding. Resin-soaked stumps were excavated and removed with crawler tractors, harvested portions of the watershed were burned in May 1979, and woody debris [and considerable soil (Morris and others 1983)] was pushed into parallel windrows with a large (101 kw) crawler tractor with a shearing blade (Morris and others 1983). Areas between windrows were disked in August with a 3-m-wide offset disc pulled by a crawler tractor-- creating a relatively clean mineral soil surface. Machine bedding and planting was conducted as on the companion WS 1. We refer to this as the maximum treatment.

Surveys

Crown cover for each plant species were recorded in six surveys; one (in the summer of 1977) prior to harvest and five in subsequent summers at plantation ages 1, 2, 3, 5, and 7 years. Survey techniques were described in detail by Conde and others (1983). Briefly, crown cover was repeatedly measured to the nearest dm along vertical projections of 10-m transects and cover was calculated by summation of these values. There were 26 of the 1977 transects within the area subsequently regenerated by the minimum method, WS 1, and 24 transects within the clearcut area on WS 2 regenerated by the maximum method.

Separate surveys were concurrently conducted for biomass (in 1977-78, 1980, 1981, 1982, 1984, 1986). Preharvest overstory biomass was determined by destructive sampling of six 100-m^2 plots. Preharvst midstory biomass was determined by destructive sampling of a 25-m^2 subplot within each plot. Preharvest understory and post harvest biomass (excepting pines) were determined by destructive sampling of several distinct, smaller subplots in each plot (Conde and others 1983). These latter subplots were rotated within plots in successive years (to avoid effects of previous sampling) and comprised 5 m^2 per plot in the 1977-78 survey, 8-m^2 per plot in the 1980 survey, and 6-m^2 per plot in each subsequent survey. Planted pines were not harvested--rather biomass was estimated using equations of Gholz and Fisher (1982).

Cover statistics were much easier to obtain, and are more reproducible in successive surveys, involving as they do remeasurements of permanently marked transects that are not disturbed by observation. Thus, changes in cover (barring recording errors) reflect only changes in the vegetation. Conversely, destructive biomass sampling necessitates movement of field plots in successive years, implying that some variation in successive observations is added due to inherent spatial variation in the stand.

RESULTS AND DISCUSSION

Both watersheds had very similar cover in overstory slash pine and competing vegetation prior to harvesting and site preparation (Table 1). Cover of slash pine has increased at about double the rate on maximum treatment WS 2 compared to the minimum treatment WS 1 following harvest, site preparation, and planting. Although cover of competing trees, shrubs, and vines was reduced substantially by both treatments, the reduction was much greater on WS 2. In addition, the woody competition has recovered much slower on WS 2 where, after 7 years, cover of trees, shrubs, and total woody competition was less than half the level found on WS 1. Only vines were increased on WS 2 and this increase is minor in terms of total woody competition. On WS 1, cover of shrubs and total woody competition has nearly reached preharvest levels after 7 years while cover of woody competition on WS 2 is still well below this level. Unlike woody competition, the herbaceous understory was not diminished by site preparation, but rather was stimulated by clearcutting. This increase in herbaceous cover was due to an increase in grasses on WS 1 and to an increase in forbs on WS 2 where the increase was somewhat greater, especially at ages 3 and 5 years. By age 7 years the cover of herbs had returned to preharvest levels on WS 1, but it was still somewhat above this level on WS 2.

Changes in foliage biomass were somewhat different than for cover. Slash pine foliage biomass was the same through age 7 years on both watersheds as was foliage biomass of competing trees (Table 2). Foliage biomass of shrubs did, however, follow the same trend as shrub cover, recovering more slowly on WS 2 and being less than half that found on WS 1 at age 7 years. Biomass of herbaceous competition increased more following treatment than did the cover of herbs. The increase in biomass occurred in the grasses and to a lesser extent in the forb group on both treatments. Although herb biomass declined over time, it was still about double the preharvest level after 7 years on both watersheds.

1.-- Cover of slash pine and competing species by life form before (1977, 78) and after (1980, 81, 82, 84, 86) harvesting, minimum and maximum site preparation and planting on a north Florida flatwoods site.

ment[1]	Cover					
	'77-78	'80	'81	'82	'84	'86
	----- percent -----					
	Slash pine					
mum	57.2	0.3	0.6	4.1	12.1	17.5
mum	58.7	0.5	3.0	9.3	17.8	27.0
	Competitive trees					
mum	10.6	1.7	3.1	2.5	3.2	4.4
mum	13.7	0.2	0.2	0.5	1.0	2.0
	Shrubs					
imum	81.5	18.4	21.8	33.5	57.2	71.0
imum	77.2	3.3	9.2	16.9	27.6	25.3
	Vines					
imum	1.4	0.1	0.3	0.3	1.1	1.8
imum	1.4	0.1	0.1	0.6	3.4	6.0
	Total woody competition					
imum	93.5	20.2	25.2	36.3	61.5	77.2
imum	92.3	3.6	9.5	18.0	32.0	33.3
	Grasses					
imum	35.7	27.7	39.3	41.2	41.9	31.6
imum	30.1	19.7	23.2	33.9	39.1	39.1
	Grasslikes					
imum	3.0	4.4	2.0	1.4	1.6	0.4
imum	3.3	11.0	5.9	5.4	3.5	1.8
	Forbs					
nimum	7.1	6.9	8.0	9.7	8.2	3.6
ximum	3.4	9.2	21.4	23.5	25.2	12.8
	Ferns					
nimum	1.0	0.7	0.9	0.9	1.9	4.7
ximum	1.3	0.3	0.1	0.2	0.4	0.1
	Total herbaceous					
nimum	46.8	39.7	50.2	53.2	53.6	40.3
ximum	38.1	40.2	50.6	63.0	68.2	53.8

Minimum treatment consisted of clearcutting, chopping, bedding, and planting. Maximum treatment was clearcutting, stump removal, burning, shearing and piling, discing, bedding and planting.

Table 2.-- Foliage biomass for slash pine and competing vegetation by life form before (1977, 78) and after (1980, 81, 82, 84, 86) harvesting, minimum and maximum site preparation and planting on a north Florida flatwoods site.

Treatment[1]	Foliage biomass					
	'77-78	'80	'81	'82	'84	'86
	----- kg/ha -----					
	Slash pine					
Minimum	4787	12	22	704	1333	2306
Maximum	4524	21	128	194	1236	2069
	Competitive trees					
Minimum	326	0	11	3	12	7
Maximum	373	3	1	6	7	15
	Shrubs					
Minimum	1811	436	634	1008	1698	1340
Maximum	1291	454	389	600	730	533
	Vines					
Minimum	4	25	8	28	109	147
Maximum	35	3	3	9	218	139
	Total woody competition					
Minimum	2141	461	653	1039	1819	1494
Maximum	1699	460	393	615	955	687
	Grasses					
Minimum	148	917	960	1385	769	369
Maximum	339	1458	762	992	954	577
	Grasslikes					
Minimum	15	188	66	58	15	3
Maximum	3	560	83	61	24	14
	Forbs					
Minimum	21	224	206	252	102	20
Maximum	36	504	593	427	122	55
	Ferns					
Minimum	18	52	15	24	17	8
Maximum	4	0	1	7	2	7
	Total herbaceous					
Minimum	202	1381	1247	1719	903	400
Maximum	382	2522	1439	1487	1102	653

[1] Minimum treatment consisted of clearcutting, chopping, bedding and planting. Maximum treatment was clearcutting, stump removal, burning, shearing and piling, discing, bedding and planting.

Maximum site preparation controlled woody competition better than the minimum treatment. The cover data indicates the slash pine responded to the reduction in woody competition on WS 2 and this response should continue for a few more years because the woody competition is still at a lower level. The growth response by slash pine is also apparent in height and diameter data. At age 7 years, mean diameters and heights were 7.82 cm and 5.8 m on WS 1, and 8.58 cm and 6.5 m on WS 2. The lack of an apparent response in the biomass data is likely due to the smaller sample size and greater variation (cf. Surveys).

In the South deficient soil nutrients limit pine growth on many forest soils and are not available at low moisture levels (Glover 1985). The reduction of competition results in an increase in pine growth because moisture, nutrients, and light are made available for use by pines rather than competing species. Although inherent site quality is not changed by competition control, it can result in a more efficient capture of the potential tree growth. This results in a shorter rotation age as it takes less time to reach a selected product size or total volume of wood. On the basis of the cover data pines on WS 2 are about 1 year ahead.

Mechanical site preparation normally increases rather than reduces herbaceous competition (Nelson 1978), and the more intensive the treatment generally the greater the response by the herbs. Fortunately, the herbaceous species decline rapidly as the woody species take over, soon returning to preharvest levels. All of these trends are quite evident in the cover and biomass data from this study. Thus, both treatments may have created a short-term negative response for pine growth by increasing herbaceous competition.

Often when one component of the competition is reduced it will result in a corresponding increase in another component (Cain and Mann 1980). This did occur to a degree on WS 2 where herbaceous competition increased more than on WS 1. The amount of increases, however, was not as large as the reduction in shrubs, and overall competition was less, as shown by the increased growth of the pines on this treatment.

As noted earlier, long-term pine growth in plantations is closely related to the proportion of hardwood trees in the stand. The relationship is curvilinear and even relatively low levels of competing hardwoods can substantially reduce pine yields (Glover and Dickens 1985). For example, the model by Burkhart and Sprinz (1984) predicts an increase in competing hardwood basal area from 10 to 30% would decrease pine yield by 75%. On the basis of cover, WS 1 is 80% slash pine and 20% competitive hardwood trees, while WS 2 has 93% and 7% slash pine and competing hardwoods, respectively. It is hard to relate this to past work which is all based on the percent of hardwood basal area. However, if the reduction in the hardwood component lasts, pine yields at rotation age should be greater on the maximum treatment.

Past studies have shown a general trend of decreasing competition in subsequent pine stands as the intensity of the site preparation increases (Haines and Pritchett 1965, Schultz 1976, Schultz and Wilhite 1974). Therefore, the better control of competition and greater pine growth on WS 2 could be expected.

However, the maximum treatment is not the better of the two unless the greater pine growth justifies the extra costs. Based on data from Straka and Watson (1985) the maximum treatment costs about $90 more per acre than the minimum treatment. This is a substantial amount and a less-expensive chemical treatment may have given similar competition control and pine growth. In addition, the growth advantage on WS 2 and the extra growth that could be expected because of less hardwood competition may be offset before rotation age is reached due to nutrient deficiency-caused growth loss, which commonly occurs after about age 10 when crown closure takes place. This is quite likely on WS 2 because of the movement of large quantities of nutrients into the windrows where they are largely unavailable for pine use (Morris and others 1983). Therefore, even though maximum site preparation does give better competition control which results in greater initial pine growth, its high cost and potential for subsequent nutrient deficiency-caused growth loss appear to make it undesirable. Long-term growth data are needed before this is known for certain.

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